CHAPTER 4 – REACTIONS IN AQUEOUS SOLUTION

Section 4.5 – Concentrations of Solutions

1. What is the definition of molarity (*M*)?

2. A student added 54.8 grams of sodium sulfate to a 500.0 mL volumetric flask. How many moles of sodium sulfate were added to this flask? Show the setup for your calculations below.

3. About 300 mL of water was added to the 500.0 mL volumetric flask. The solution was swirled and mixed until all of the solute dissolved completely. Then additional water was added to the solution until the bottom of the meniscus was even with the calibration mark on the neck of the flask. The flask was stoppered and inverted a few times to ensure complete mixing.

   (a) What is the final concentration (*M*) of the sodium sulfate in this solution? Show the setup for your calculations below.

   (b) What is the molar concentration of each ion present in this solution?

   (c) How many grams of sodium sulfate are present in 36.7 mL of this solution? Show the setup for your calculations below.

   (d) A chemist needs to use 0.150 mol of sodium sulfate in an experiment. How many milliliters of this solution would be required to obtain this amount of sodium sulfate? Show the setup for your calculations below.

4. A chemist needs to prepare a solution of 0.100 *M* $CuSO_4$ by diluting a stock solution of 1.00 *M* $CuSO_4$. The total volume of 1.00 *M* $CuSO_4$ available in the laboratory is 250 mL. If the chemist needs to prepare 2.00 L of 0.100 *M* $CuSO_4$, is there enough stock solution available to complete this task? Justify your answer with a calculation.

Section 4.6 – Solution Stoichiometry and Chemical Analysis

1. Solid calcium hydroxide reacts with solution of nitric acid.

   (a) Write a balanced molecular equation for this neutralization reaction.

   (b) How many milliliters of 3.0 *M* nitric acid are required to completely neutralize 5.0 g of solid calcium hydroxide? Show the setup for your calculations below.

   (c) How many grams of solid calcium hydroxide are required to completely neutralize 25.0 mL of 3.0 *M* nitric acid? Show the setup for your calculations below.

2. What is the definition of a titration experiment?

3. Name three types of reactions for which a titration experiment can be conducted.

4. A 25.0 mL sample of acetic acid (of unknown concentration) was added to an Erlenmeyer flask. A few drops of phenolphthalein (an acid-base indicator) were added to this acid solution. The acid solution was titrated with a standard solution of 0.500 *M* potassium hydroxide, which was used to fill a buret. The initial volume reading on the buret was 2.35 mL. At the end point of the titration (when the solution turned pink) the final volume reading on the buret was 24.87 mL.

   (a) Write a balanced molecular equation for the neutralization reaction that occurred in this titration experiment.

   (b) What volume of potassium hydroxide was used in this experiment?

   (c) Calculate the molar concentration (*M*) of the acetic acid solution that was titrated. Show the setup for your calculations below.

   (d) Suppose that the standard solution used in this titration was 0.250 *M* KOH instead of 0.500 *M* KOH. How would this change have affected the volume of standard solution required to reach the end point? Explain.

   (e) Suppose that the standard solution used in this titration was 0.500 *M* $Ba(OH)_2$ instead of 0.500 *M* KOH. How would this change have affected the volume of standard solution required to reach the end point? Explain.

5. In a different titration experiment, 1.25 grams of a solid monoprotic acid was added to an Erlenmeyer flask. The acid was dissolved in 100 mL of distilled water. A few drops of phenolphthalein (an acid-base indicator) were added to this acid solution. The acid solution was titrated with a standard solution of 0.250 *M* sodium hydroxide, which was used to fill a buret. The initial volume reading on the buret was 4.72 mL. At the end point of the titration (when the solution turned pink) the final volume reading on the buret was 29.21 mL.

   (a) Write a balanced molecular equation for the neutralization reaction that occurred in this titration experiment. Assume that the formula of the monoprotic acid is HX.

   (b) What volume of sodium hydroxide was used in this experiment?

   (c) How many moles of sodium hydroxide were used in this experiment?
   Show the setup for your calculations below.

   (d) Calculate the molar mass of the monoprotic acid used in this experiment.
   Show the setup for your calculations below.

   (e) Suppose that this titration experiment was repeated. In the second trial, 1.25 g of the solid monoprotic acid was dissolved in 110 mL of distilled water instead of 100 mL. Would you predict that the volume of 0.250 M NaOH required to reach the end point should be higher than, lower than, or the same as the volume you calculated in part (b)?
   Justify your prediction with an explanation.